Seismic Hazards in the Vicinity of Las Vegas and Reno

Annual Project Summary

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Investigations Undertaken

We have continued our researches in earthquake hazards in the two major urban areas of Nevada: the Las Vegas area and the Reno-Carson City area. We have undertaken gravity survey, waveform modeling, site amplification and basin response study. Our long-term goals are to develop a complete probabilistic and deterministic model of the seismic hazards affecting both areas, and to develop scenario ground motions that each of the major faults could cause, including basin responses.

Results

We have completed a gravity survey and analyzed the data in the Reno-Carson City region. The result was interpreted for a model of the basins beneath these cities (Abbott and Louie, 2000). The result indicates that the basin depths beneath these cities are generally less than 1 km, with a few significant sub-basins deeper than 2 km. Figure 1a shows the basin thickness distribution for the Reno-Carson City region. Figure 1b is the basin thickness structure for the Las Vegas areas. The maximum depth west of Frenchman Mountain in Las Vegas is almost 4.9 km.

Using the density and thickness structure of the Reno-Carson City region (Abbott and Louie, 2000) and the Las Vegas area (Langenheim et al., 1999), we have constructed P- and S-wave basin velocity models using the empirical velocity-density relation of Gardner et al. (1974) and assuming a poisson solid for the medium. We compute the SH-wave synthetics for the west-east sections through the deepest points of the Reno and Las Vegas basins (Figure 2). The results show the generation of strong Love-wave trains at the basin edges closest to the sources, as Vidale and Helmberger (1988) produced with similar synthetics for the 1971 San Fernando earthquake. Maximum SH velocities are 2 or 3 times larger over the basins than over bedrock, even in the relatively small Reno basin. The 4-km-deep Las

Vegas basin produces horizontal reverberations that continue more than 80 seconds, as been observed during the 1992 Little Skull mountain earthquake.

We have completed the study of site amplification and basin response on strong motion in Las Vegas. We have obtained site response functions in 9 sites in Las Vegas. We found five out the seven stations on sediment have Fourier spectral amplifications that average at least a factor of five greater than the rock reference sites from 0.5 to 2 Hz. We also generated synthetic seismograms, including the site amplification, for magnitude 7.4 earthquakes on the Death Valley fault system 150km from Las Vegas. The synthetics have average peak accelerations ranging from 0.058 to 0.13g at the rock and from 0.051 to 0.22g at the sediment sites. The average peak velocity and displacement is 49 cm/sec and 33 cm, respectively, on the larger component of a sediment site.

We also studied earthquake high frequency spectral decay parameter kappa by examining aftershocks in Southern Nevada. The parameter kappa is commonly considered as a site effect after correction for path attenuation. In our study, however, we find there is a substantial contribution to kappa from the earthquake source. By inverting source, site and path factors from kappa, we find the kappa source factor is correlated to earthquake stress drop. It increases with increasing stress drop. The large variation in kappa measurements at a station is greatly reduced after kappa source factors have been removed. The result of the kappa source dependency indicates that the commonly used w^{-2} source model is not adequate to describe the source spectra of these aftershock events.

We have made important progress in study normal faulting earthquake and its ground motion simulation. First we have studied the Mw6.4 Dinar earthquake in southwestern Turkey, 1 October 1995. This earthquake has a normal faulting mechanism. It caused 90 deaths, over 200 injuries, and a large amount of damage. The fault system, layout of Dinar city and the basin structure in many ways resemble that of Reno, Nevada. Thus understand the damage of the Dinar earthquake will greatly help the earthquake hazard estimation and reduction program if any similar event strikes Reno in the near future. We have generate a specific composite source model that reproduces the statistical characteristics of the ground motions, and approximately reproduces the low frequency waveform in the strong motion. In this model the fault length is L=12.5 km, its width is W=17.3 km, and its moment is $Mo=4.72x10^{25}$ dyne-cm. The fault strikes 130^o and dips $45\ ^o$, from the surface to 12 km. For the composite parameters, the largest subevent (R_{max}) is 4.0 km, the rupture velocity is 1.5 km/sec, and the subevent stress-drop is 60 bars. After Anderson (1997), the composite source model parameters imply that the static stress drop was 36 bars, the radiated seismic energy in this event was $4.3x10^{21}$ ergs, the apparent stress was 18 bars, and the Savage-Wood ratio was 1.0. The source model is consistent with surface faulting and SAR interferometry. The results were wrote in two papers and have been submitted. Second, we have also cooperated with Jeff Keaton on generating synthetic normal-faulting-earthquake seismograms and made procedure for scaling earthquake records to match acceleration response spectra for engineering design. The result will be presented at the EERI 6th International conference on Seismic Zonation.

We have compiled information that will allow more reliable seismic hazard maps for the Reno-Carson City and Las Vegas metropolitan areas. This information will be made available to the update of the national probabilistic seismic hazard maps of 2000 by USGS.

Non-technical Summary

The objective of this project is to conduct research on earthquake hazards in the two rapidly developing urban areas of Nevada: the Las Vegas area and the Reno-Carson City area. We have conducted gravity survey, obtained 3-D basin structure. We have estimated site amplification and basin response. These results will significant improve our understanding of the seismic hazard in these two cities. Consequently, these studies will provide the critical information to engineers in their designs on earthquake resistance buildings and large structures.

Publications

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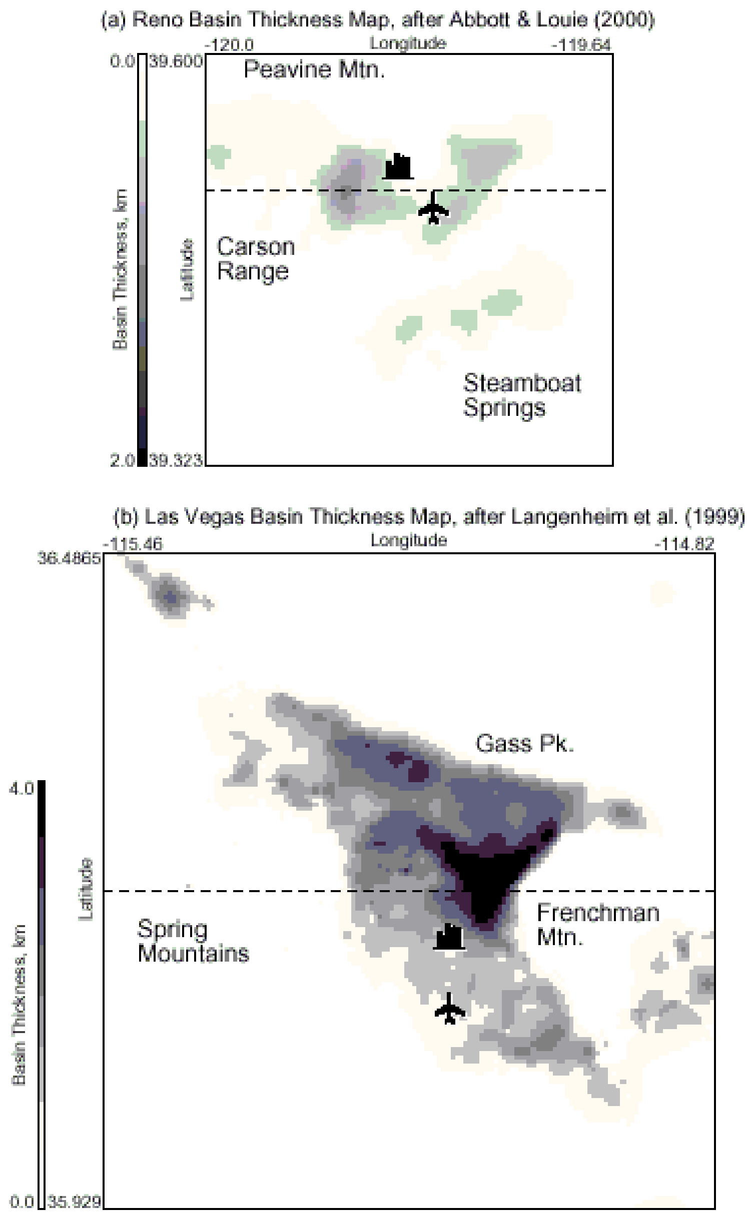

Figrue 1. Basin thickness maps for the Reno and Las Vegas areas, based on gravity and borehole data synthesized by Abbott and Louie (2000) for Reno, and including refraction data from Langenheim et al. (1999) for Las Vegas. Maximum basin depth under west Reno is between 1.0 and 1.5 km; the maximum depth west of Frenchman Mtn. in Las Vegas is almost 4.9 km. The dashed lines locate the west-east sections for 2-d modeling, 30.2 km wide for Reno and 57.4 km wide for Las Vegas. The building and airplane symbols locate city centers and airports, respectively.

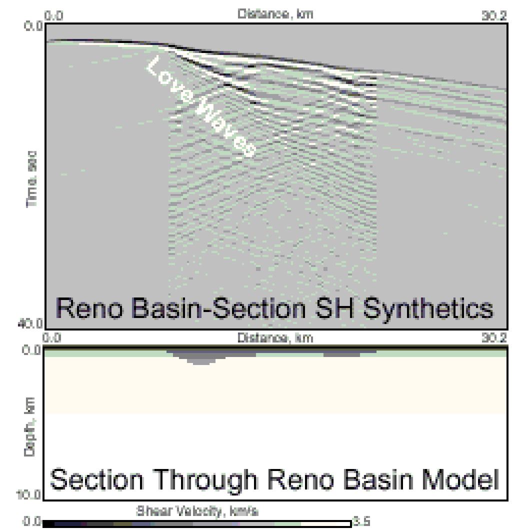

Fig. 2. SH-wave synthetics for west-east sections through the deepest points of the Reno and Las Vegas basins. V_S and density sections were constructed from basin depth maps, assuming ν=0.25 and basin-density relations from Blakely et al. (1999). 2-d seismograms were computed with the method of Vidale et al. (1985) for a simple one-sided impulse source at 8 km depth, 2 km from the western edge of each model. Note the generation of strong Love-wave trains at the basin edges closest to the sources, as Vidale and Helmberger (1988) produced with similar synthetics for the 1971 San Fernando earthquake. Maximum SH displacements are 2 or 3 times larger over the basins than over bedrock, even in the relatively small Reno basin. The 4-km-deep Las Vegas basin produces horizontal reverberations that continue more than 80 seconds.